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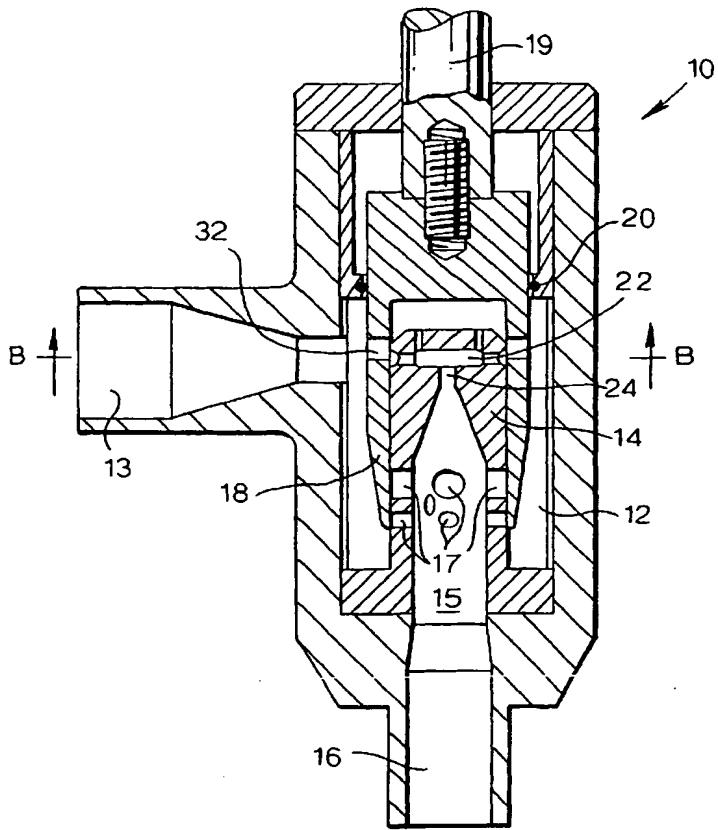
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(54) Title: VALVE ASSEMBLY



(57) **Abstract:** A valve assembly (10) comprises a valve stem (14) with a bore (15) and radial apertures (17), and a sleeve (18) closed at one end and slidable over the valve stem (14) to obstruct the apertures (17). At the end of the valve stem opposite the outlet end, the valve stem (14) defines a fluidic vortex chamber (22) with both tangential inlets (28) and non-tangential peripheral inlets (26), and with an axial outlet (24) communicating with the bore (15). The sleeve (18) defines at least one radial port (32) near its closed end. The valve assembly operates in a conventional fashion except when approaching closure. Once the last of the apertures (17) in the valve stem has been closed, the only flow path is through the fluidic vortex chamber (22). Further movement of the sleeve (18) alters the distribution of the flow between the non-tangential inlets (26) and the tangential inlets (28), so adjusting the strength of the fluidic vortex and the resistance to fluid flow. The valve assembly (10) suppresses erosive and cavitation wear of the valve mechanism, and can provide a wide range of flow modulation.



SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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- 1 -

Valve Assembly

The present invention relates to a valve assembly that may be used to control a flow of a fluid, and that 5 resists damage from erosion or cavitation, and to a use of it.

The use of a purely mechanical valve in which a valve member seals against a valve seat is very widely 10 known, and can be used either to adjust the flow of a fluid or to close off the flow altogether. Such a valve is not entirely suitable for use in controlling flows of potentially abrasive fluids, for example the liquids emerging from an oil well that may contain sand 15 particles, as the particulate material will cause abrasion of the valve surfaces especially when the valve is almost closed. Fluid flows can also be controlled, as described in GB 2 209 411, by a fluidic vortex valve or vortex amplifier, in which the main flow enters a vortex 20 chamber radially and leaves the chamber axially, and a flow of liquid is supplied to a tangential inlet by a suitable pump; the magnitude of the tangential flow has a very large effect on the main flow, as it generates a vortex in the chamber. Such a fluidic vortex amplifier 25 can be used as a choke valve, and has the benefit that it suffers much less from abrasion. However a fluidic vortex amplifier must always have fluid emerging from it, since if the main flow is to be effectively shut off then the flow of the control fluid must be at its maximum.

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According to the present invention there is provided a valve assembly comprising a valve stem defining a bore and at least one radial port, and having an outlet end, and a sleeve closed at one end slidably over the valve 35 stem to obstruct the or each radial port in the valve stem, wherein the valve stem at the end opposite the

- 2 -

outlet end defines a fluidic vortex chamber having at least one generally tangential inlet and at least one non-tangential peripheral inlet and having an axial outlet communicating with the bore, and the sleeve 5 defines at least one port near the closed end of the sleeve.

The valve assembly operates in a conventional fashion except when approaching closure. Once the last 10 of the radial ports in the valve stem has been closed, the only flow path is through the radial port in the sleeve, and hence through the fluidic vortex chamber. Initially the flow is primarily through the non- 15 tangential peripheral inlet or inlets, but on further closure of the valve the radial port in the sleeve aligns with the tangential inlet to the fluidic vortex chamber, so a fluidic vortex is generated and the resistance to fluid flow is increased. In the final approach to closure, substantially all the fluid flow must pass 20 through the tangential inlet or inlets, the resulting vortex maximizing the pressure drop but minimizing the erosion of the surfaces. Finally the flow is stopped altogether as the valve stem obstructs the radial port in the sleeve.

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The erosive and cavitation wear on the mechanical valve mechanism is significantly reduced as compared to conventional choke valves, particularly at the low flow/high pressure drop conditions in which erosion is 30 most severe. A wide range of flow modulation can be achieved with limited movement of the mechanical valve member, as closure is approached.

Preferably there are a plurality of non-tangential 35 peripheral inlets that communicate with the end face of the valve stem. Preferably there are also a plurality of

tangential inlets, and these are preferably linked by a peripheral groove on the outer surface of the valve stem. There may also be a plurality of radial inlets through the sleeve, lying in a common radial plane.

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Thus the vortex chamber provides the flow path for the bulk of the fluid only when the valve assembly is almost closed, that is to say only at very low flow rates through the valve assembly. In contrast, when the valve 10 assembly is fully open, substantially all the fluid passing through the valve assembly bypasses the vortex chamber. However, when the valve assembly is almost closed, the vortex chamber provides the flow path and also the bulk of the pressure drop across the valve 15 assembly.

The invention will now be further and more particularly described, by way of example only, and with reference to the accompanying drawings in which:

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Figure 1 shows a cross-sectional view through a valve assembly;

Figure 1a shows a fragmentary view of part of the 25 assembly of figure 1; and

Figure 2 shows a sectional view on the line B-B of figure 1.

Referring to figure 1, a valve assembly 10 comprises a valve chamber 12 of substantially cylindrical shape and which communicates on one side with an inlet supply port 13 for a fluid flow to be controlled. A tubular valve stem 14 projects from one end wall of the valve chamber 12, and its bore 15 communicates with an outlet duct 16; the valve stem 14 defines a plurality of radial apertures

- 4 -

17 through its walls.. A valve sleeve 18 closed at its top end (as shown) fits over the valve stem 14 and can be moved axially by an actuator (not shown) by means of a valve stem 19, passing through a seal 20 at the other end 5 wall of the valve chamber 12. Movement of the valve stem 19 consequently controls the degree to which the apertures 17 are obstructed, and so controls the flow of the fluid passing between the inlet 13 and the outlet duct 16. These features are substantially conventional.

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Towards its top end (as shown) the bore 15 tapers; the valve stem 14 is almost closed at the top end, but defines a fluidic vortex chamber 22 with an axial outlet 24 communicating with the bore 15. Referring also to 15 figures 1a and 2, there are eight narrow inlet ports 26 extending parallel to the longitudinal axis and equally spaced around the periphery of the chamber 22, providing fluid communication between the top end of the valve stem 14 and the periphery of the chamber 22. There are also 20 four tangential inlets ports 28 extending in a radial plane from the periphery of the vortex chamber 22, and at their outer ends communicating with a groove 30 around the outside of the valve stem 14. The ports 28 are shown diagrammatically in figure 1; their orientation is shown 25 more precisely in figure 2. The top end of the valve stem 14 is chamfered around its edge.

The sleeve 18 defines four radial apertures 32 a short distance below the closed end. The radial 30 apertures 32 are located such that as the sleeve 18 is lowered, the apertures 32 start to communicate with the circumferential groove 30 just as the last radial apertures 17 is closed. As shown in figures 1 and 1a, the apertures 32 are wide enough to communicate both with 35 the groove 30 and also with the space above the top end of the valve stem 14 (because of the chamfer). If the

sleeve 18 is lowered to its fullest extent, flow is completely stopped because the apertures 32 are obstructed by the portion of the valve stem 14 below the circumferential groove 30.

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Hence in use the valve assembly 10 operates in a conventional fashion except when approaching closure. As the sleeve 18 is lowered, it gradually obstructs the apertures 17 (which in this example are of progressively smaller diameters), so gradually restricting the fluid flow. When the valve sleeve 18 reaches the position shown in figure 1 the only flow path is through the radial apertures 32, and then through the fluidic vortex chamber 22, leaving through the axial port 24 and so into the bore 15. In this position the flow is primarily through the space above the valve stem 14 and through the inlets 26, but on further lowering of the sleeve 18 the apertures 32 align with the groove 30 so that a greater proportion of the flow is through the tangential inlets 28. A fluidic vortex is therefore generated in the vortex chamber 22 and the resistance to fluid flow increases. On still further movement of the sleeve 18, fluid access to the space above the valve stem 14 is completely obstructed so all the fluid flow must pass through the tangential inlets 28, the resulting vortex in the chamber 22 maximizing the pressure drop across the assembly 10 but minimizing the erosion of the surfaces. Finally the flow is stopped altogether as the apertures 32 are blocked by the wall of the stem 14 below the groove 30.

Thus as the valve assembly 10 approaches closure, a progressively greater proportion of the overall pressure drop is due to the fluidic vortex rather than to the mechanical valve components.

- 6 -

It will be appreciated that a valve assembly may differ from that shown in the drawings while remaining within the scope of the invention. For example, the apertures 32 might be at such a position that, when the 5 last aperture 17 is just closed, the apertures 32 communicate only with the space above the valve stem 14; only on further movement of the sleeve 18 would the apertures 32 then communicate with the tangential ports 28. Instead of, or in addition to, the peripheral groove 10 30 on the valve stem 14, there might be a circumferential groove on the inside wall of the sleeve 18 linking the apertures 32. The non-tangential inlets 26 might be inclined at an angle to the longitudinal axis, for example communicating with the chamfered corner of the 15 valve stem 14. And evidently the numbers of apertures 17, 26, 28 and 32 might differ from that described and shown.

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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 F16K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 778 928 A (COPES REGULATORS LTD) 26 March 1935 (1935-03-26) page 2, line 41 – line 82 page 3, line 19 – line 54 figure 1 ---	1-4
A	US 4 397 331 A (MEDLAR LEWIS A) 9 August 1983 (1983-08-09) column 5, line 42 -column 6, line 68 figure 1 ---	1-4
A	US 3 990 475 A (MYERS EDWARD B) 9 November 1976 (1976-11-09) column 2, line 22 -column 4, line 43 figures ---	1-4 -/-

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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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